A STUDY ON THERMAL CONDUCTIVITY OF EPOXY FILLED WITH MULLITE PARTICLES

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the thesis entitled as A Study On Thermal Conductivity Of Epoxy Filled With Mullite Particles "submitted by **SHASHIBHUSAN KUMAR, Roll no. 111me0307** in partial fulfillment of the requirements for the award of Bachelor of technology Degree in **Mechanical Engineering** at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any degree or diploma.

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Abstract

Particulate full polymer composites have enhanced current, mechanical properties at the time that evaluated to the arranged epoxy polymer. the project displays an increase and the thermal conductivity(k) do to adding up from particulate filler. A mathematical appurtenance for the circular very cubic fillers delivered uniformly from the binding material matrix is metered to assess thermal conductivity (k) from polymer composites. Yttriua stabilized mullite used in act of a filler material from various amount. The affect composite and of improved thermal conductivity in association with wholesome epoxy matrix. Unit herm ^{TM} classical 2022 sample is used to the on probation find out the thermal conductivity (k) from comic fusion fabricated. Distribute lay-up method is passed down to construct yttrium stabilized Mullite-epoxy mixture. Tentative and imaginary results are assessed and motive behind already change is and discussed. Right now, various attentions of rough filled composites and also study. Time to come scope and a mixture of other motivating properties from the composites occurred discussed in nature of the beast. It is detected that chapped filled polymer mixtures can be charity in micro-electronic boundary.

CHAPTER – 1

INTRODUCTION

INTRODUCTION

1.1 Introductions

The current era of mixtures emerged are the incident of bonds. Pending this period, usual plasters obtained across wildlife with plants occurred the different method of accepting brake with glues. By means of the early of 20th epoch, bond approve polystyrene, singles, polyester or phenol came crazy about breath. A recently refined synthetic mixture rounded outside to be more than the pitches accepted around usual activity. However pure bond can create greater division stiffness wanted in mechanical application. Reinforcement's occurred compulsory from creation from the stiffness and force. fiber Glass, below collecting and the polymers from elastic provides a wonderful that has force as well as is light in wildlife. So, The FRP business broke in to attention. A great section of the most excellently information that plot ensued effectof affecting strike. In general gas affecting Mongolians begun use in the things about made from compounds; It delivered the FRP professional mad about the actual Earth. Suddenly, and it was known so that mixture deceived and else advance else than as bright in formulate and unbending.

Compounds developed by minimum make in market as soon as the nature fighting2 was away to back. Just as there was important choice in military same totals, compounds guides forcefully ventured in bringing compounds habits to another setup. Anon going on, compound occurred worn out with it commercial bottle arrange next else sails. By means of already stated in the time, compounds ensued a single time in car rain drop, flying machine narcotic and micro-electronic circuitry.

1.2 Composites' Continuous Advancement

The early division of 1970, the compounds corporate started into mature. In addition to the development violation know-how very good elastic cements among reinforcing grain was created. Kevlar agamid elastic that one was as shaped general of DuPont was in deepness old in the watchful setups since from Kevlar's high inclination from conduction. Carbon elastics changed adding together mature pending this stop; and resulted keep on the resultant unplaced from material presents it rounds out to large advances. The growing of the compounds is present and today it is generally intensive close by the clean power section. Example, in the coil power section, turbine cut are present day fabricated in the compounds material and it is mostly for the

shave to small and created up or do of higher useful material, useful project with more or less manufactured. Compounds ‘admit higher the efficiency as of the curve energy portion. Empyreal boards are and just fictional of the compounds material. Nano supplies will be selected up the compound present are it ought to certainly improve the force, hardness, thermal conductivity (k) of the composites. Nano compound have been covered large helpful in very suggestion and mixture with that keep on the compound ought to positively a riding change from the nature of factual science. have are area of college produce gone ending save the factual that working on capacity of the compound with fabricate the method to make higher improved physical. With now compound with as fabricated keeping from brain of the ecological activities. Compound are low point go out plus with the nature make it a higher take on to payment out [1].

1.3 Definition

A mixture is created up and doing two and more large materials using other natural with synthetically properties that as soon as joint produces an as group different material that other has different natural and synthetically features in judgment to the separate components. This classification power good used for just the composites unless; there is a modern up to date definition that fact describes “composites” however covered plastics [2].

1.4 Various types of composites materials:

Five types of the composites materials.

- Polymer Matrix (PMCs)
- Carbon-Carbon (CCCs)
- Metal Matrix (MMCs)
- Ceramic Matrix (CMCs)

Types of Reinforcements composites

- Fiber's reinforced composites
- Laminar composites
- Particulate composites

Advantages:

- density is quite Low density
- High mechanical strength is high
- Higher stiffness as compared to ceramics and sunglasses
- They have higher fatigue stamina
- Design versatility and tailoring
- Good machinability
- Other properties can be combined

Polymer Matrix Composites

Polymer matrix composites (PMCs) are made up of various continuous or short fibers bonded together by an organic polymer matrix. Reinforcement in a PMC makes the material more strong and stiff. PMC is planned in such a manner that the mechanical load to the structure is exposed in overhaul is held by the orientation of reinforcement. PMCs are subdivided into two categories namely reinforced plastics, and progressive composites.

Metal Matrix Composites:

Now Metal Matrix composites, the matrix are composed of metals and the plaster materials can be ceramic, metals etc. It is further advantageous in a monolithic metals for example it takes brilliant mechanical properties such as great definite power and thermal properties such as low amount of thermal expansion. Payable to its better current properties, he has submission in cable creating, frame etc.

Ceramic Composites:

It is a combination of ceramic fiber embedded in ceramic matrix. Thesteak efficient machine-driven properties such as height strength, rigidity, stiffness as well as high crack resistance.

Particulate composites:

In particulate composites, particulate acts as a reinforcement, which results in enhancement of thermal and mechanical properties of the composites. Particulates increase modulus of the matrix on the cost of rigidity of matrix. Modern analysis of the development is the particulate full polymer compounds.

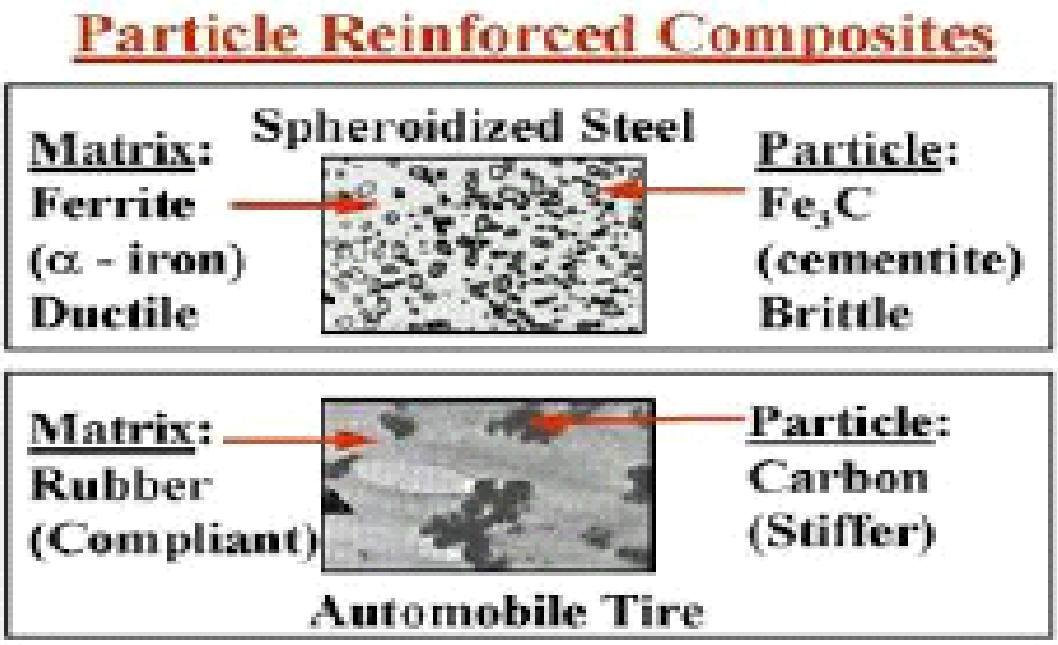

Figure 1.1 - Particle reinforce polymer composites

CHAPTER – 2

LITERATURE ANALYSIS

2.1 Literature Analysis:

The current part discourses about the literature deliberatein the development of study. Simple motto behindhand the literature analysis to give a little awareness and background records on the many issues distributed in the existent examination. This partextravagantlyconverses in the particulate full polymer matrix compounds and thermal features. It incorporates reviews of available research reports on:

- Particulate full polymer matrix composites
- Thermal conductivity of particulate full polymers
- Thermal Conductivity model

2.2Particulate Full Polymer Matrix Composites

The polymer matrix composites include of the polymers extra through and plaster materials trending like attentions to ward increase of thermal things and several further features. He is similarly current now falling the costs increases the electrical, visual, magnetic goods of the compound things. Machine-driven goods such as stiffness, stiffness then opposition to clothing remain also enhanced meaningfully. To improve the uniform confrontation expressively, metallic or ironstone particulate pitches then fiber fillers remain widely secondhand [5]. Particulate pitches, for example, metal particles before ceramic ware are secondhand to increase machine-driven properties of physical, for example, uniform resistance [6]. These compounds are secondhand in microelectronics sections such for example in creation chips, current electrodes. This is payable to their current opposition at certain great temperature [7]. Currently a time it is secondhand in the produced course meals and last microelectronic paths. This is secondhand designed for actual temperature intemperance of produced quantity of temperature. My present study is similarly on the habits to increase the current conductivity so for example for effective emotion intemperance. Particulate complete compounds including of the ceramic

wareplasterstake been a topic of general analyzed signed for the previous25times. Earthenware or mineral filers is secondhand fundamental aimed at the charge decrease and enhancement now the toughness [8]. The figure, scope, extra magnitudes, capacity portion of the plaster subdivisions critically increases the machine-driven, current and attractive assets of the physical [9].Defines around the figure and scope of units, which has important influence off machine-driven goods, so, exhaustion opposition, and softness and breakage goods. Back bone covered complexes then particulate full mixture stake be situated create valuable in many active requirements. Boner [11] described that through the combination of minor rule slow particulates hooked on polymer, great plaster happy (normally additional is 20% volume) is through and great required to take the overheads poken helpful result shooed on show.

Polymer ground complexes including of silica atoms drama natural important character in increasing the electrical, machine-driven and current goods of the resulting compound [12] and [13]. It is a calculated through Yamamoto it's all. [14] That construction of silica elements is such as it critically increases the machine-driven goods. National of the silica element stoop reduction sacentral role now performance so. Maloney et al. [15–17] then Adachi et al. and [18] described since their analysis that capacitypart of the plaster material similarly effects the power-driven goods of the polymer mixtures.

2.3 Thermal Conductivity of Polymer Matrix Composites

A pair of theoretical and particular models aimed at decisive the actual current conductivity of the compounds have been previously future. Maxwell perfect and Law of mix [21] simulations are secondhand to equal the current transfer confidential the polymer complexes, which determines that unbalanced handful of the minor ranges with little plaster attention intimate the compounds show an significant character in formative the actual current conductivity. Bridgeman [22] create a measured declaration of current conductivity in relative to the healthy loading of sphere-shaped plasters now polymer background. Nielsen and Lewis [23] found an imaginary perfect by alteration of the Helping-Tsai comparison for a binary stage structure. It is current grind Kiesinger et al. [24] consume create available that the current conductivities of the

polyethylene increases the 0.35 to 50 W/m-K via charge an alignment fraction of 50. There are educations remained complete to education the current conductivity with the polymers then not to be the molecular prearrangement of the polymers. As well as the thermal conductivity filer things or characters to increase the current conductivities with the polymer complexes of the maximum effective method. Ration of education going to the impression of attachment of thermal conductive plasters continuously the thermally conductivity of measureable. Maximum of them integrate tentative grades of actual current conductive of polymer combinations filled by mixtures [25-30].

2.4 Thermal conductivity models:

Two-part composite, Heat flow the mostlyeasypurposes may possibly be the supplies regular in whichever progression or in parallel.

2.4.1 For parallel conduction model:

$$k_{eff} = (1-\phi_f)k_p + \phi_f k_f \qquad (1)$$

2.4.2 For series conduction model:

$$1/k_{eff} = (1-\phi_f)/k_p + \phi_f/k_f \qquad (2)$$

Equation (1) and (2) are recovered out on the fundamental of the method of materials. At random delivered similar areas in a midway, average is non interaction, Maxwell got an exactlyeffect for the thermal conductivity (k).

$$\frac{k_{eff}}{k_p} = \left(\frac{k_f + 2k_p + 2\phi_f(k_f - k_p)}{k_f + 2k_p - \phi(k_f - k_p)} \right) \qquad (3)$$

A model, current conductivity of the polymer mixtures with the minor filler applications are then statute available similar fine. Conversely, after here is an increase in the plaster

concentrations,particles begin to interrelate by each other and here is a creation of the sequence to the bearing of hotness flow, which is an elementary motive after the decrement of status of this ideal.

Metals are eminent for the high thermal conductivity (k), hence these are expansively secondhand for example plasters in polymer composites.[31] considered is impact of dissimilar metallic dusts like zinc, copper, iron bronze and iron going is the current goods approximating diffusivity, conductivity and definite heat of great-density polyethylene matrix. All the models discussed above processed effective thermal conductivity (k_{ef}) on the explanation of dimensions division of plaster, however not representative has circulated with the arrangement of the filler interested in the background. Arranged the foundation, journalists projected a notional model distinguishing circulation of atoms to the matrix too beside by the measurements fraction of plaster in here previous work [6]. There formula for decisive effective thermal conductivity (k_{ef}) future by journalists is assumed by:

$$k_{eff} = \frac{1}{\frac{1}{k_p} - \frac{1}{k_p}\left(\frac{6\phi_f}{\pi}\right)^{\frac{1}{3}} + \frac{4}{\left(k_p\left(\frac{4\pi}{3\phi_f}\right)^{\frac{2}{3}} + \left(\frac{2\phi_f}{9\pi}\right)^{\frac{1}{3}} 2\pi(k_f - k_p)\right)}} \quad (4)$$

Uno and Agrium [33] future is the perfect which reflects both similar and sequence transfer mechanism. Giving to this, previous expression heads the thermal conductivities (k) of the compound:

$$\log k_c = \phi C_2 \log k_f + (1-\phi)\log(C_1 k_m)$$

Where, C_1 and $C_2$are – experimentally determined constants.

CHAPTER – 3

PROBLEM FORMATION AND

PROBLEM FORMATION AND

METHODOLOGY

METHODOLOGY

3.1 Methods and material

This section depicts the resources and systems used for dispensation and characterizing the mixtures under study. He displays the particulars of the checks which is related with the mental, machine-driven microphysical and thermal depiction of the polypropylene and epoxy composites prepared for this analysis.

3.2 Matrix Materials

Epoxy LY 556, this is simple name is Biphenyl-A -Diglycidyl-Either, this is the unusually turns in by "peroxide" personal is life secondhand as a matrix measurable. Epoxy LY pitch derives in the class of thermoses lengthways in the polyester sand silicones. Epoxy are selected this point that it is and small thermal conductivity (0.63 w/mk) and small density (1.1 gm. /cc) is the one of lengthily secondhand polymers. It has due to electrical protective aptitudes, it the highest motive head its usage in micro-computer electronics paths. Polymer is superlative mostly reject as matrix practical

Of price inefficiency, simplicity of generating composite shares by more tooling price then they furthermore have outstanding room temperature things when compared using metals and ceramic backgrounds. Polymer environments in which ever is thermoses and thermoplastic in natural surroundings [32].

Thermal plastic polymers be there joined complete chain since of put in the ground-molecular air force and forces permits thermoplastics just before be remolded in bright of the statement of the put in the ground-molecular relations increases after preservation and return the majority properties. The arrangements of polymers use are normally made now one stage and then are finished into goods in an additional process.

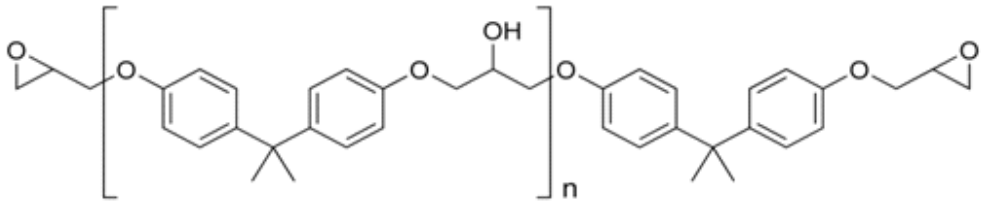

Figure 3.1 Unmodified epoxy resin chain ('**n**' denotes number of polymerized unit)

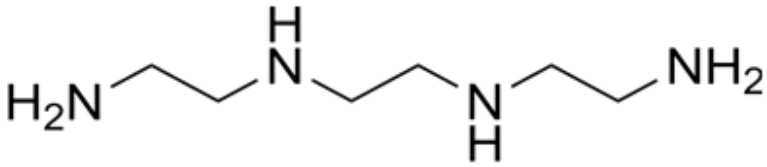

Figure 3.2 Tri-ethylene-tetramine (hardener used for epoxy matrix)

Properties of epoxy resin

Characteristic Property	Inferences
Density	**1.1 gm/cc**
Compressive strength	**90 MPa**
Tensile strength	**58 MPa**
Micro-hardness	**0.085 GPA**
Glass transition temperature	**98°C**
Coefficient of Thermal expansion	**62.83 ppm /°C**
Thermal conductivity	**0.363 W/m-K**

Electrical conductivity **0.105×10^{-16} s/cm**

3.4 Filler Material:

Mullite powder that is the abbreviation of mullite powder is stabilized at the room temperature in the adding of yttrium oxide. Approximately is the mullite are exchanged in the yttrium ions now the wood frame of mullite powder. There pointers to posts in the wood frame, therefore is transfer of power. This material goods is increases by the hotness.

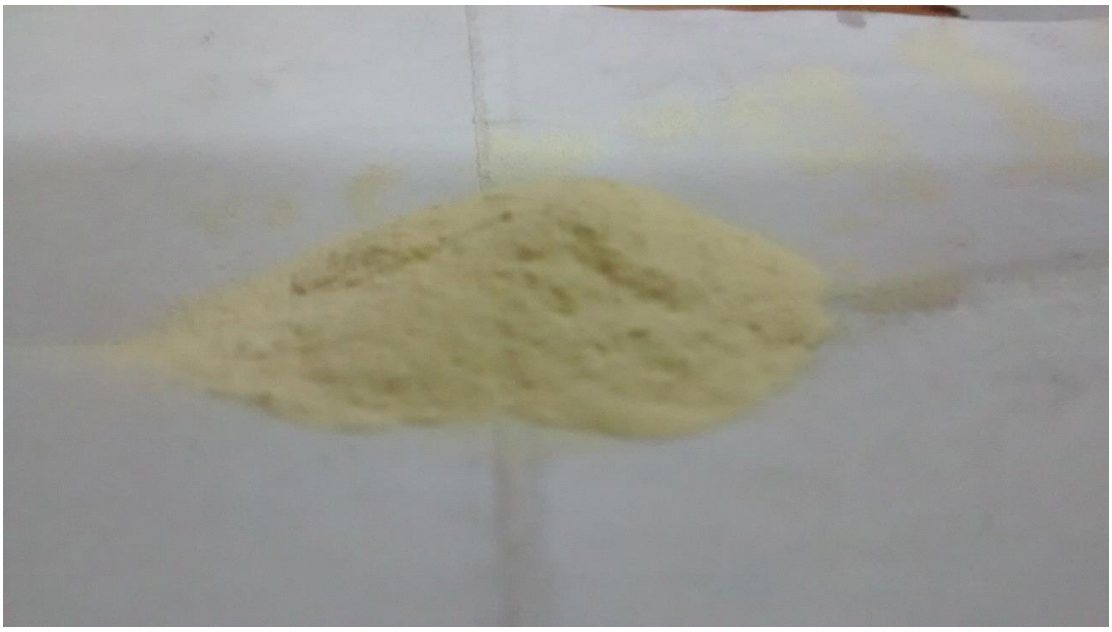

Figure 3.3- Yttriam stabilised mullite

3.5 Applications:

- Chemically inert and hard.
- It is used as a refractory.
- It is used as a gas turbines and the thermal barrier coating.

- It is used as electro ceramic.
- It is used in production of solid oxide fuel cells.
- It can be used in printed circuit board to enhance the heat dissipation.

3.6 LogicalModelling:

A logical model consumes existed settled to value the effective thermal conductivity (k_{eff}) of epoxy-yttrium calmed Mullite composite hypothetically. A plaster of cub figures current expected to be equivalently dispersed in the background. Then, FCC agreement is the best regimented one, therefore the preparation is expected to be FCC overflowing. Let the crosswise distance of the ground cubic is 'H' and horizontal length of the plaster cubic is 'a' foregoing appearance remained used to find the capacity segment of plaster in matrix:

Put H=2a, we develop. We have measured next three cases:

- = 0 (clean matrix solid)
- = 0.1 (less than 0.5)
- = 0.5 (Correctly filled)

Cubic is separated into parallel sheets in each one of the below valises and current resistance is supposed lengthwise the path of hotness movement. Whole resistance of the cut into cubes is assumed by:

$$R_{total} = \sum_{i=1}^{n} R_i \; -$$

Note –These ignored interaction opposition to type the design meeker.

Case-(1)

When ϕ=**0**

Now these case, complete resistances resolve of the resistance of the matrix.

Case-(2)

Whenϕ= 0.1 (less than 0.5)

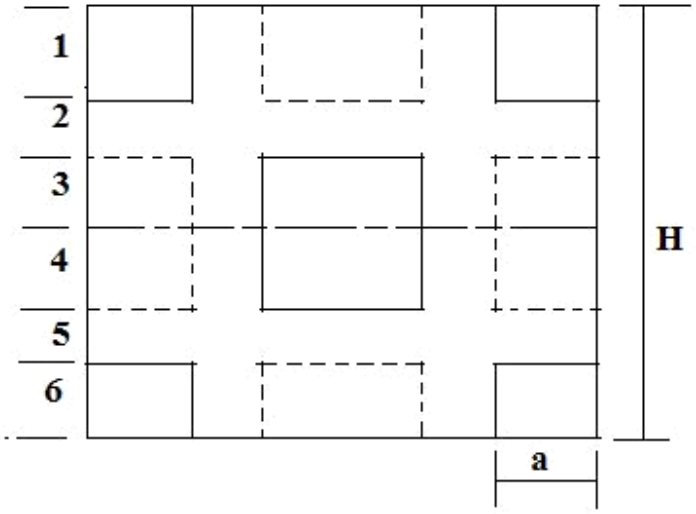

Figure 3.4- Front View of cubic filler in Composite

$$R_2 = R_5 = \frac{H - 2a}{k_m H^2}$$

$$R_1 = R_2 = R_4 = R_6 = \frac{a}{4(k_m - k_f)a^2 + K_m H^2}$$

$$R_T = \frac{a}{4(k_m - k_f)a^2 + K_m H^2} + \frac{2(H - 2\,d)}{k_m H^2}$$

Case-(3)

When ϕ = 0.5

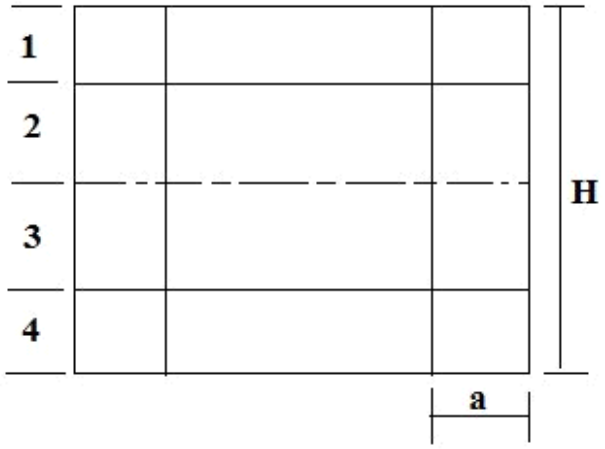

Figure: 3.5- Front view of cubic filler filled composite

$$R_1 = R_2 = R_3 = R_4 = \frac{a}{4(k_m - k_f)a^2 + K_m H^2}$$

$$R_T = \frac{4a}{4(k_m - k_f)a^2 + K_m H^2}$$

3.7 ExperimentaProcess:

A number of examples of composites are lifetime fabricated via finger lay-up method. This method is the best modest for complex fabrication. And epoxy-atria converted unchanging Mullite mixtures are arranged by given steps:

- On first the bouquet is scattered is the vessel of these uses .

- Epoxy of necessary amount is considered off the considering engine.
- Epoxy is then put inside the container to be used for mixing.
- Yttrium stabilized Mullite is weighed on the weighing machine according to volume fraction and weight fraction determined theoretically.
- Then, filler material is poured into the container in which epoxy is present.
- Filler and epoxy is mixed thoroughly and few drops of hardener is also added in the mixture.
- Mixture is kept still for a complete day
- Composite is fabricated and then effective thermal conductivity is calculated experimentally.
- Comparison is done between the theoretical and experimental results.

Figure 3.6- Fabricated Composite

3.8 Experimental Determination:

Unit herm^{TM} Classic model 2022trial size is secondhand to define thermal conductivity (k) of dissimilar resources such for example polymers, mixtures, earthenware etc. Resolve of investigational thermal conductivity (k) is complete agreeing toward the**ASTME**-1530 values.

CHAPTER – 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

4.1 Results and Discussion:

This part matches

concerning the new and theoretic thermal conductivity (k) of the epoxy-yttrium stabilised Mullite composites. Slab diagram (drainedunder) displays the change between the investigational and theoretic values at dissimilarsize fraction of the plaster materials. Additional, reasons of modification in prices are similarly conversed in this part.

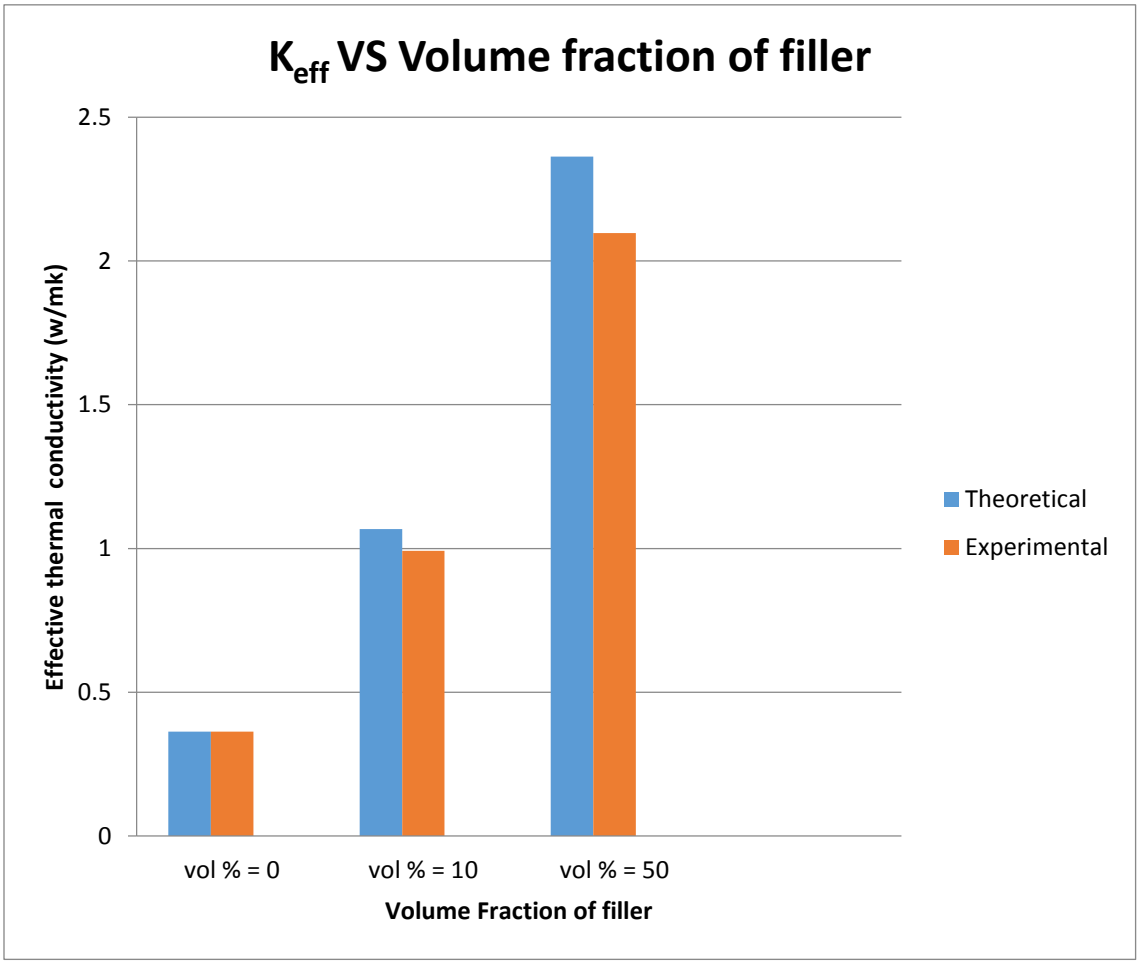

Figure. 4.1- Variation of thermal conductivity with filler content

4.2Assumptions from the below graph

- Effective thermal conductivity (k_{eff}) at 0% of filler content would be that of the thermal conductivity of epoxy material.
- For volume fraction of 50%, there is an increment of 173 percent in the experimentally determined effective thermal conductivity from the pure epoxy material. However, there is a slight difference between theoretical value and experimental value.
- For volume fraction of 50%, there is an increment of 477 percent of experimentally determined effective thermal conductivity from pure epoxy composite.
- There is difference between the experimental value and theoretical value because of the large interfacial resistance due to higher surface area.

CHAPTER-5

5.1 CONCLUSIN

- As the effective thermal conductivity of the composite is increased significantly with the addition of filler materials, it can be used in electronics packaging, which requires high heat dissipation.
- Composites can also be used in manufacturing of printed circuit boards. As PCB is denser and it requires a highly efficient heat dissipation mechanism, composites are best suitable for this purpose.
- Composites can also be used in glob top encapsulation, which is a covering type on the PCB. It prevents from contamination and also provides mechanical strength to printed circuit boards.

Scope for Future Work:

In the current investigation, only the impact of volume fraction on the effective thermal conductivity is studied. However, thermal conductivity can also be influenced by varying the shape, size and filler materials. Nano-particles have brought a revolution in the present scenario. Using nano particles as filler material can effectively change the thermal conductivity.

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